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MONTHLY REVIEW

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EDITORIAL

Your Co-operation Is Needed

Every year at the close of our annual Convention, the election of officers takes place and into their hands is delivered the responsibility of the numerous details connected with the Society for the coming year.

The President is chosen because of his ability to do things, and in nearly every case he is an outstanding member of the organization previous to his elevation to that important office. He deems it a high honor and governs himself accordingly. All of our presidents have dignified the office to which they were elected. Inasmuch as there is no salary attached, it is the duty of every member to loyally support the President. Likewise the other officers elected with him. The Secretary-Treasurer and Editor by reason of the tasks imposed upon them are salaried employees of the American Electro-Platers Society. They too should receive the co-operation necessary to the best interests of the respective offices. None but these holding or having held office in the Supreme Society can fully realize the amount of work involved. Honesty, faithfulness, cheerfulness and determination are some of the requirements necessary to successfully conduct the same.

It is the purpose of this article to ask for more co-operation with the work of the Editor's office. We have received numerous letters from our membership regarding the REVIEW, all of them

sincere and unsolicited thanking us for "the bigger and better publication" as some have styled it. Of course we are human and are pleased to say that all such letters are appreciated very much, and are filed away for safe keeping. Yet there is something we desire in order to keep the REVIEW interesting and up to date, that is the co-operation of the Branch Societies from Boston to California, Canada included. Less than a dozen of our branch Secretaries report the doings of their branches regularly. Splendid papers are read at nearly every meeting. Questions are asked and answered but we don't receive them for publication. The following Branches report regularly every month:

Philadelphia	Detroit
Hartford-Conn. Valley	New York
Rochester	Los Angeles
Chicago	Anderson
Cleveland	Newark
Waterbury	

These Branches report fairly often but not every month:

Boston	Worcester
Bridgeport	Providence
Dayton	Baltimore-Washington
Milwaukee	

Boston, Dayton and Milwaukee have been sending splendid reports in lately.

Toronto	Toledo
Montreal	Indianapolis
Pittsburg	St. Louis
Cincinnati	Grand Rapids
San Francisco	

Report only occasionally.

Now, branch Secretaries, we are not fault-finding or criticizing, our sole aim is to give the readers of the Review the very best information we can procure. We heartily appreciate the support given us by a great many of our readers and if it is expecting too much to report every meeting, as the larger branches do, will you not co-operate with us in sending in the papers read at your branch meetings, and report other things of interest to our membership at large as often as is possible?

SHALL WE EXTEND OUR RESEARCH?

By Jos. H. Hansjosten

The following article, submitted by Mr. Jos. H. Hansjosten of Detroit Branch (C. M. Hall Lamp Co.), has considerable merit.

A discussion on this subject through the pages of the "Review," would prove interesting and instructive. Our readers are asked to send in their comments, which we will gladly publish.—[Editor.

To produce a better electro deposit is the ideal every plater seeks to attain, and to aid him in obtaining that object he formed a platers' society, wherein to exchange ideas with other platers, give of his knowledge and experience and take of the knowledge and experience of his fellow men. United in a society he is able to explore in a scientific manner by means of research fields not well known to him and obtain information that would be quite beyond his reach as an individual. Through his society he has formed classes in chemistry in which he learns the methods used to analyze and control plating solutions.

Until now his quest for knowledge has been largely confined to the chemistry and electricity of plating, with but little study of the numerous other phases of the metal finisher's art, some of which are so important that it is admitted that the appearance of the finished article depends on how well or how poorly they are done. For no matter how efficient the plating department may be, if the polishing and buffing is inferior an inferior finished product is the result. Not only may we look for greater perfection in polishing and buffing, but it seems to be within the proper sphere of the society to work for more scientific methods to determine costs and develop methods more efficient than those now in use. In short, the question is: Is it not the American Electro-Platers Society's duty to promote research into every field related to the plating and finishing of metals? If the answer is Yes, then it is our plain duty to make investigations and do research work in polishing and buffing.

There are signs that there is an awakening to the necessity of giving more time to the study of methods and ways of doing work prior to plating. (For the purpose of this paper, we will treat cleaning as a part of the plating operation.) More interest is being taken in polishing and buffing, and more will be taken in those operations

as the necessity for improvements in them becomes more apparent. We have acquired the habit of giving all our time and thought to plating, so that we just take polishing and buffing for granted, and the methods and ways of the past were accepted by us and we continued using them without improving them; in fact, we allowed polishing in many cases to degenerate into but little better than a rough grinding operation.

We will grant that some attention is paid to the ingredients of the buffing compositions, because as platers we have learned by bitter experience that an excess of unsaponifiable matter will cause trouble in the plating department. The use of mineral oil on polishing wheels has likewise become tabu for the same reason. But have we gone into any of the other details in those operations? Some of the men in charge of plants have and are now doing research work in their plants, and the result is lower costs. Some of the larger plants have "polishing engineers" who are continually investigating and experimenting with the thought in mind that improved methods mean improved products at a lower cost.

That at least some attention is being paid to the subject under discussion is proven by noting that the Chemical Engineering Department of the University of Michigan is making a series of "Studies in Metal Polishing" with the Associate Professor of that department in charge. In the January issue of *The Metal Industry* Mr. A. P. Munning suggested the formation of a "Finishing Engineers' Society" to study this subject. It must seem a very important matter to him, and his suggestion of another society to investigate metal finishing may have been prompted by the utter indifference with which the platers' society regards this, to the plater, very vital subject. Instead of another society, will it not be better if we, as a society, extend our scope and do the work ourselves?

In the May issue of THE MONTHLY REVIEW is a paper by Mr. Ernest Lamoureaux, in which, among other very pointed and true statements, he says "really good polishing on steel or iron has become a lost art." A strong statement, but we know that it is true. The neglect that polishing has suffered has resulted in a poor grade of work that is, as a rule, covered with a quite thick coat of nickel, and then to get a color much of the nickel is buffed off and leaving the article but little suited to resist wear. Mr. Lamoureaux further states that if only a small percentage of the investigations and

researches of recent years in the plating field had been devoted to similar work in polishing and buffing, a great deal of grief in plating would have been avoided.

In an address to Detroit Branch, Mr. Robert T. Kent stated that "polishing is now where grinding was thirty years ago." Certainly a strong indictment from so eminent an authority, and all the more stinging because it is true.

At the Birmingham meeting of the Electro-Chemical Society last April, a paper was read explaining equipment used in the research work that is being done at the University of Michigan. This seems to indicate that the members of that society are at least interested in the subject.

A year ago last April, in a paper read before Milwaukee Branch, Mr. Jacob Hay, chairman of our Research Committee, suggested that every phase of metal finishing is properly a part of the plater's work. And is he not correct? For who can deny that wherever the polishing and plating departments are under separate heads passing the buck becomes a popular indoor sport?

The foregoing seems to be evidence enough to prove that our research work should include polishing and buffing.

We are at present conducting research work to determine the durability of various deposits. And we will get some very valuable information from the work being done. But would not the information be more valuable if the finish on the base metals was as carefully determined as the deposit plated over it? Would it not be interesting to find if the deposit on a well polished piece of steel or iron lasted longer than the one on a poorly polished piece? Does not that seem a point well worth investigating?

Has it ever been conclusively proved that a poorly polished piece of steel or iron is less costly than a well polished piece? We know we can reduce the cost of polishing by reducing the number of operations or the number of wheels used in doing the work, thus making the operation cost less. But have we ever determined how much more it costs us in labor, buffs, composition and power to nickel buff that piece? And if a certain thickness of nickel is specified, how much of the deposit is buffed off in nickel buffing? We know by experience that more nickel is buffed from a deposit on a poorly polished piece than from a piece that is properly finished, but we have never scientifically determined how much and we do not know; we are not sure that we are saving anything

by doing poor polishing; in fact, we may be doing what Mr. Lamoureaux suggests we are doing, "Robbing Peter to Pay Paul."

Actual tests proved that 4.8 grams per square foot of nickel was buffed from a well finished surface, and over 5 grams per square foot were buffed from a fairly well finished surface. How much more is buffed from a poor job of polishing?

Would not some dependable and accurate information on the foregoing questions prove interesting, if not valuable? Is it not a fact that we are still groping in the dark here, still going by rule of thumb, just guessing? Then why not apply scientific methods to this and like subjects that are of such interest to us?

Cotton is the material buffs are made of, and a buff means just so many discs of that cloth, enough to use for the work to be done. May it not be possible that there is some less costly material to replace it? For some buffing operations paper is now used. Why not find how much work can be done with it, how far it can be substituted for cotton in buffing?

The buffing operation is a costly one, and it is certainly worth while to give it some thought.

Many as are the details of buffing, they are multiplied in polishing. Wheels, abrasives, glue and speed are all important enough to be scientifically approached, and this provides another field for investigation. Why ignore it?

Recently much has been said of the outside plating expert, and many platers actually fear that the day of the foreman plater is a thing of the past. It is not. For the foreman plater who knows his "stuff" knows how to analyze and control his solutions, who is not only a plater but knows how to control costs in his polishing and buffing department so that the firm that pays him can meet the new competition, will be in greater demand than ever, for we are in an era in which competition is as keen as it ever has been, and the foreman plater must not only know his chemistry, but he must also become a polishing and buffing "engineer," if you please, to meet the competition the other fellow is giving him for his "job."

So why not let our society extend the scope of its research in fields so close to plating? Conditions really demand it. If there is a "better way" let's find it, and do things that way.

(A paper prepared for the November meeting of Detroit Branch)

*HIGH SPEED NICKEL-PLATING AS PRACTISED IN ENGLAND

By Ernest R. Canning

Read at Rochester 1931 Convention

(Read by Mr. C. H. Eldridge)

In England, current densities of 2.2 amps./sq. dm. and over are used. Continuous filtration of the electrolyte, except at 32° to 35° C., is necessary to eliminate suspended foreign matter and pinholes. Due to considerable loss in throwing power, the author advises against very high current densities. The preferred pH is 5.6 to 5.8. The cathode efficiency is 96% to 97%. A plate 0.001" (0.025 mm.) thick is obtained in forty-five minutes, with a variation in thickness of not more than 45%. For adequate protection of the steel, a nickel plate of at least 0.001" is necessary. For sub-tropical countries, composite deposits of nickel-copper-nickel are recommended.

The English practice of high speed nickel-plating was described by E. J. Dobbs in a paper entitled, "The Commercial Deposition of Nickel," read before the Electro-Platers' and Depositors' Technical Society in England in 1926. Here, the practice of nickel-plating as carried out at several English manufacturing concerns was outlined. The paper described the process whereby current densities of 24 amps./sq. ft. (2.6 amps./sq. dm.) were quite normal, and this involved the use of a warm nickel solution which was agitated by means of compressed air, and continually filtered by the same means.

Dobbs pointed out that with current densities of twenty amperes/sq. ft. (2.2 amps./sq. dm.) and over agitation of the electrolyte was necessary to avoid the possibility of forming pinholes. This agitation by means of clean air served a double purpose, as it also had the effect of oxidizing any organic matter which may be present in the solution, and which may arise from dust particles floating in the air, or can occur from extraction of the soluble constituents of the wood lining of the vat. The air agitation thus acted mechanically and chemically, and was found necessary for high speed plating.

With the advent of agitation of the solution, a fresh trouble was encountered, namely, roughness of deposit. It can be appreciated that any slight insoluble impurities in the nickel anode are set free by the dissolution of the nickel, and these, under the effect of the

*American Electrochemical Society, Birmingham, Ala. meeting.

agitation, are in continual suspension in the solution, and tend to settle on the work and become locked up in the deposit.

To overcome this trouble, a system of continuous filtration of the solution was devised, whereby a portion of the air compressed for agitation purposes was used, on the principle of an injector, to raise a constant stream of the solution above the height of the vat, and to discharge through a filter cone back into the main solution. By these means, smooth, close-grained nickel deposits are obtained which finish easily and give the maximum protection to the base metal.

N. R. Laban, in his paper (Electro-Platers' and Depositors' Technical Society, 5-129-34), advocated a preliminary anodic etch in sulphuric acid of 55° Bé. for the purpose of increasing the adhesion of the nickel deposit to the base metal, and described the working of nickel solutions at current densities from 25 to 100 amps./sq. ft. (2.7 to 10.8 amps./sq. dm.) in commercial practice on steel parts. He worked for some years on the lines described above, used nickel solutions of pH values from 5 to 6, worked at temperatures of about 60° C., and urged the necessity of vigorous agitation of the electrolyte, together with continuous filtration and the enclosure of the anodes in bags.

Laban advised the avoidance of wood linings in the nickel vat, as the hot, slightly acid solution readily attacks the cellulose of the wood, with the formation of reducing sugars, which can contribute considerably to the trouble of pinholes. The greatest point he emphasized, however, and in my opinion it cannot be unduly stressed, is the considerable loss of throwing power associated with high current density deposition. This loss may, in some cases, be so serious as to limit the use of current densities of about 24 amps./sq. ft. (2.6 amps./sq. dm.) on certain articles. He argued that, to acquire the requisite thickness of deposit in those areas that receive a low current density, it is necessary to deposit an excess on the prominent surfaces, so that nickel is being wasted, and the whole purpose of a high current density is lost. In such circumstances, the adoption of a lower current density, with increased throwing power, is the truest economy.

The results obtained by Phillips and by Mougey do not quite coincide with those obtained in English practice, but the difference I firmly believe to be due to the general absence of agitation of nickel solutions in the United States. Laban was able to obtain

excellent results as regards the quality of the deposit, when working at a pH value of 5.0, with current densities of 100 amps./sq. ft. (10.8 amps./sq. dm.) or more, and the need for increased acidity was not manifest at this speed.

Phillips in his paper emphasizes unconsciously the enormous loss in throwing power occasioned by the use of very high current densities. He says, "These curves give data which may be used when a short plating time is used, for example, with a pH of 1.0, they show that even when the irregularity of the pieces is such that the current density between different areas varies as much as from 150 to 10 amps./sq. ft. (16.2 to 1.08 amps./sq. dm.) a five-minute plate at any temperature above 125° F. (51° C.) will give a good deposit."

Assuming that the cathode efficiency is 100%, which it is not, being about 70%, and accepting that 18.7 amperes per hour per square foot gives a thickness of 0.001" (0.025 mm.), it will be apparent that the thickness of deposit must vary from 0.00067" (0.017 mm.) to 0.000045" (0.001 mm.). Bearing in mind that the primary purpose of the nickel deposit is the protection of the base metal against corrosion, and conceding that the measure of protection afforded is the measure of the thinnest deposit, I feel that too great stress can be laid upon the speed of deposition, with a tendency to overlook the vital point of adequate protection.

O. P. Watts, in his paper entitled, "The Plating of Radiator Shells," says, "The great importance of good throwing power, when plating for the protection of a corrodible metal, like steel, is shown by a study of Table III, and of the photographs which appear later."

It is this considerable loss in throwing power, associated with the use of high current densities, that has persuaded me generally to advise current densities of the nature of 24 amps./sq. ft. (2.6 amps./sq. dm.) for nickel-plating, working the solutions at temperatures of about 32° to 35° C., with constant agitation and filtration, at pH values of 5.6 to 5.8.

The cathode efficiency under these conditions is about 96% to 97%, and thicknesses of approximately 0.001" (0.025 mm.) are usually obtained in roughly forty-five minutes, with a variation over irregular-shaped articles of not more than 45%. In special cases, as outlined by Laban, these current densities are considerably exceeded, but in general the need for adequate protection of the

base metal is the first consideration, and is rarely sacrificed for increased speed of deposition.

The thickness of nickel deposited may sound extravagant, but experience has shown that this is the minimum that can be safely applied to steel parts which are to be exposed to full atmospheric conditions prevailing in England. There the humidity of the atmosphere is considerably greater than prevails in the United States, or upon the continent of Europe, so that a much greater severity of test is imposed upon the plated articles.

Where manufacturers are jealous of the reputation of the quality of their goods, we have advised thicknesses of nickel of at least 0.001" (0.025 mm.) directly upon the steel base, or in exceptional cases, as in the humid atmospheres of sub-tropical countries, composite deposits of nickel, copper, nickel, the intermediate copper layer being buffed before the reception of the final nickel coating.

MR. ELDRIDGE: Now, I had occasion not long ago to abstract this article, Mr. Laban's article, that is quoted so freely, and, briefly, Mr. Laban advises, "A current density with a temperature range to match and a nickel concentration to match." He speaks of high, medium and low current densities. Low current density is considered 25 amps./sq. ft. or below, with a temperature range of from 77° to 95° F. Medium current density is considered from 25 to 50 amps./sq. ft., with temperature range from 95° to 122° F. High current density, above 50 amperes/sq. ft., temperature above 122° F.; and with a current density above 70, Mr. Laban recommends 140° F. For the medium current density, it is recommended that the content of single nickel salt vary from 1½ to 1.8 pounds per gallon. For higher current densities, that is, from 50 to 70 and above, he recommends single nickel salts vary from 1.8 to 2½ pounds. The plating formula used by Laban is, approximately, 8.4 ounces per gallon of nickel, given as single nickel salts, boric acid three ounces a gallon, nickel chloride content not given; useful pH range, 5 to 6. [Applause.]

CHAIRMAN O'CONNOR: Are there any questions to be asked Mr. Eldridge regarding this paper?

MR. H. H. WILLIAMS: I haven't anything on this paper, but, before you close, would like to get back at Mr. Phillips for a remark he made about St. Louis.

MR. PHILLIPS: That was in reference to the atmosphere. Outside of that, St. Louis is a wonderful city.

There is just one word I would like to say about the paper. It is the same paper that was read in Birmingham. I sort of take exception to Mr. Channing's remarks that I was unconscious while I was talking. I don't speak in that condition at all.

In the next place, the question of throwing power, as I mentioned this morning, is one that is rather relative. If you have your electrode distances of sufficient magnitude, a little lack in throwing power doesn't make so much difference. Mr. Channing refers to 45% difference in his own plating. If we would double the thickness, we would more than make up the difference on the thinnest part, which is very readily possible with a low pH bath.

MR. PHILIP SIEVERING: I would like to ask Mr. Phillips whether his figures were right,—400 grams per liter of nickel salts, which he spoke about before. Is that correct?

MR. PHILLIPS: We used 400 on the high concentration bath. On the low concentration bath, 250. That is the one we usually use, 250.

DR. BLUM: I would just like to ask Mr. Phillips if the American plants have tried air agitation in nickel-plating, and whether they find that it has any of the advantages that Mr. Channing cites.

MR. PHILLIPS: I would be afraid to use air agitation in a high pH bath, unless I had a very good filtration system. Now there might be a possibility of an advantage in a low pH bath being kept clean. But putting air in a nickel bath is very dangerous. We haven't tried it anywhere, except in an experimental way, but we didn't find any great advantage.

MR. H. H. WILLIAMS: In reference to the tarnishing of chromium plating, there is no doubt that there are elements in St. Louis that cause trouble. We have heard about it in the city recently. But I think some of it is due to inspection of some of the products before they are sent into St. Louis. A little over two years ago, a member of St. Louis Branch bought a Detroit made car, and on the hood, after he had it about two days or so, he noticed a bad spot, and he took it back to the dealer, who replaced it with a new shell. After he had that shell for a short time, it also showed imperfections in the same place. So he said he wouldn't fool with them any longer, and he took it off and had one of the job shop men there in St. Louis chromium plate it, and he had very little trouble with it after that. During the Detroit Convention he had an opportunity to visit the shop that made that car, and he said that when he was in the buffing department, after it was nickel buffed, he said

that of the shells that went through there six or seven out of every ten were cut through in that same spot.

Now I will say for Mr. Phillips' benefit that it wasn't a General Motors product, but nevertheless it shows the condition in which some shells go out, and also it helps to emphasize Mr. Phillips' statement that there must be a good coat of metal underneath.

Now, we have one shop doing commercial work, that is, in their own line. They had a great deal of trouble, complaints of tarnishing of chromium. Their plater insisted that they take a piece of their work, set it out in the yard, and then have a man just simply wipe off one half of that article every day, and I forget the period that it was out there, but even at the end of the period the part that was just wiped off every day was almost as good as the day it went out there, where the other side commenced to peel and lift off. That subject came up in a newspaper just two weeks ago, about another certain article that the School Board had purchased for outside work, and we took the liberty to reply to the School Board. On account of that article being published, I think it hurts the plating industry. And we told them we didn't think there was anything magic about chromium plating, that it would not throw oxidizations off, but the oxidizations must be wiped off in some way. And I don't think that it can always be blamed on to the base metal. I think it is logical to suspect that there must be some little care given it. Now, if Mr. Phillips has a different idea, I would be glad to hear it.

MR. PHILLIPS: I think all of us would be delighted if the customer would take care of the product. Our jobs would be much easier; we wouldn't have any depression, everything would be lovely. But that is not the case; you have to make things for the average careless person, to some extent. I think motor car manufacturers and other people might emphasize the fact that a little care would help an awful lot.

TARNISHING OF CHROMIUM PLATING

By W. H. Phillips

Read at Rochester 1931 Convention

Gentlemen, I want to say first of all that the heading of this paper is somewhat a misnomer. I haven't seen chromium tarnish yet. But it was reported to us that it was tarnishing, and almost in spite of ourselves we had to almost agree that it looked that way.

But on looking into the matter we found that the tarnish was caused by thin plates of nickel underneath the chromium, or no plates at all of nickel. That is, where brass or copper was used either as the base material or the base plate.

This first example here is a hub cap which you can see by looking at the bottom is brass. It had some nickel on it, but not enough. Oddly enough, this difficulty occurred in St. Louis only, in the beginning. We have since found some isolated examples of the same thing in other sections, but it was referred to first of all as "St. Louis Browns." Not that it was always brown; it was sometimes yellow, and was very puzzling and somewhat difficult. We found, on scraping off the coating, that the coating was composed of oxides of copper and zinc where brass was the base metal, or copper only where copper was the base metal.

These two papers, the one I gave this afternoon and this evening might well have been read together, because the answer to the difficulty here is simply observing the heavy plates suggested or made possible by the paper this afternoon. We get the same difficulty on zinc die castings where copper is used as the deposit.

We are still puzzled as to the reason why this should happen in St. Louis more than any other district. We suspect that it is on account of chemical factories there. I say we have since found some examples in Detroit, one or two in New York and some other districts.

The only purpose of the paper is to call to your attention the necessity of getting a good, heavy nickel deposit underneath the chromium. By a good, heavy deposit, in this case, I mean about two ten-thousandths of an inch or better.

That is all there is to this paper, unless there are some questions.

BUFFING COMPOSITIONS

With special reference to the methods and materials employed in finishing chromium irons and steels

By L. R. Eastman

Read at Rochester 1931 Convention

The subject of buffing compositions covers such a wide range of materials and methods that it is impossible to do more, in such a short article as this, than cover briefly some of the fundamental principles, sketch some of the high lights of its history, outline the

modern methods of manufacture, classify the raw materials and products in a general way, and then to illustrate, by taking some example, the basic factors involved in the polishing, buffing and finishing of metals.

The finishing of chromium irons and steels has been selected as the illustration, first, because it is a comparatively new material; second, because the problem of giving it a satisfactory finish at a reasonable cost may present serious difficulties to the polishing department when, and if, it is first encountered; and third, because a better understanding of the fundamental principles of this material may, on the one hand, lead to its adoption for certain specific uses where it appears to have superior advantages, and, on the other hand, may avoid the loss and inconvenience attendant upon trying to adapt it to other uses for which it may not be suitable.

The methods and materials employed in polishing and buffing operations today have little in common with those of forty years ago. In those days the polisher bought his tallow at the butcher shop and applied it to the wheel with a swab. Tripoli composition was unknown and crocus composition was the most important product. Small batches were mixed by hand in cast iron kettles over an open fire; dipped out by hand into single molds, which were later knocked out by hand, one at a time, each cake being handled separately. Small steam-jacketed kettles were, it is true, being used by some of the larger manufacturers, but there was little to compare with the modern plant with its large mechanical mixers turning out a ton or more at a time; its accurate, technical control of raw materials, operating methods and finished products; and semi-automatic molding and knock-out machinery costing thousands of dollars which replaces the old-time single molds. All of these products of modern engineering practice make it possible to manufacture compositions of a quality and uniformity which was impossible in the early days; to do so at moderate cost of production; and to deliver uniform, high-quality products to the metal finishing industry at a reasonable price.

In addition to quality and uniformity of product, the metal finishing industry looks to the composition manufacturer for two other types of service: first, to act as a clearing house for the investigation of the countless new raw materials which are so frequently discovered or offered, or which are available for use; second, for the development of new products and methods to meet

and solve the constantly changing problems which it faces. For instance, the advent and widespread use of chromium plating made necessary the development of new products and the fundamental changing of some of the older ones. The constantly increasing application of automatic polishing and buffing is necessitating further changes, and these new conditions must be met if maximum efficiency is to be realized.

The raw materials used in buffing compositions cover an extremely wide range of products. The more common abrasives include emery, tripoli, various grades of silica, lime, aluminum oxides, crocus, rouge, pumice, and various other powders for specific products. Each of these materials is available in varying degrees of purity, hardness, size of grain and uniformity. The oils, greases and waxes are available in endless variety, the principal materials used being stearic acid, various grades of tallow, paraffin wax, petrolatum, and numberless other products of the animal, mineral and vegetable kingdom. Many of the latter are used in various products only in very small percentages, but have a very definite effect on the texture, working qualities, and ease of cleaning of the finished products. The manufacture of buffing compositions has thus developed from a simple problem to a complex one, and from a rule of thumb process to a highly specialized industry. Variations of one per cent may very easily ruin a product, and variations in the time, temperature or method of mixing may also have injurious or ruinous effects.

The methods of control of raw materials include, in the case of oils, fats and waxes, determinations of melting point, viscosity, color, odor, and other physical characteristics; in the case of abrasive powders, chemical analysis, complete screen analysis, and microscopic examination. It will be obvious that, except for certain very simple formulae and products, it is impossible for the user to determine all these factors once a number of ingredients have been intimately mixed to make the finished product. Generally speaking, the user must therefore rely upon his source, or sources, of supply for uniformity, except, of course, that he, consciously or unconsciously, relies upon his own more or less definite specifications and requirements for performance.

In developing new products to meet new conditions, and also in adapting present products to meet present conditions, the manufacturer of compositions must have the wholehearted co-operation of

the user, with mutual interchange of ideas, suggestions and information. The right product in any class can, as a rule, be determined only by taking into consideration the kind of metal, condition of the surface, type and speed of buff, sequence of operations, type of equipment and quality of finish desired. Where cleaning and plating is to follow, the methods and materials to be used in those processes must also be taken into consideration. While it is true that almost any grade of material in a given class *may* be used and will, perhaps, work reasonably well, it is also true that maximum satisfaction and efficiency can only be realized when all these factors are taken into consideration and the best possible materials and methods are employed.

With the advent of chromium plating in mass production, it became necessary to produce a more perfect finish and to do a better and more thorough job of cleaning. This involved many problems and many changes in equipment, materials and methods. Generally speaking, it became necessary to use a better quality of compositions, with faster cutting qualities, capable of producing a better finish, and with better cleaning characteristics. Higher peripheral buff speeds and higher pressures which accompanied automatic buffing also necessitated further changes. The average old-time tripoli composition, for instance, for buffing brass castings at low speeds and pressures by hand, which in many cases were not even plated, was a low melting point, low viscosity, greasy product, a comparatively soft cake, rather low in stearic acid, containing, probably, considerable sharp silica, low in price, leaving plenty of composition on the work, and requiring considerable effort to clean, to secure even the comparatively inferior degree of cleanliness necessary for straight nickel-plating, if plated at all. The modern composition, adapted for high peripheral speeds and pressures, for automatic buffing, capable of producing a much better finish in less time, and leaving a minimum of composition on the work which must be cleaned with a fraction of the time and effort formerly employed, is a hard, high melting point, tough cake, usually a pure tripoli composition, high in stearic and tallow, with a different ratio of abrasive to binder, and so compounded that it emulsifies completely in the modern cleaner with a minimum of time and effort. While it sells at a higher price per pound of composition, the unit cost of buffing for the work done is still very much less than before.

The materials, equipment, and methods employed in cleaning have received a great deal of attention in recent years. It is well known that certain types of composition are more easily cleaned than others. Ease of cleaning is determined by the nature of the binder itself and by the ratio of abrasive to binder, and, to a lesser extent, by the nature of the abrasive. The other factors involved in cleaning, such as materials, temperature, the use of mechanical agitation, or electric current, or both, the question of hand scrubbing, preliminary soaking, etc., are, of course, outside the scope of this paper. However, the nature of the composition itself is also of great importance, as affecting both the kind and amount of grease, dirt, lint and composition to be removed from the work. The composition should have sufficient lubricating qualities to avoid overheating the buff and packing undue amounts of charred lint and grease into any holes or crevices which are, of course, the real problem in cleaning. The binder should not be of such high melting point as to fail to soften under immersion for a very short time in a cleaning bath of moderate temperature. It should be so compounded as to emulsify completely and quickly in the ordinary type of commercial cleaner.

Continuous perfect cleaning can only be secured in quantity production methods when the nature of the composition is such as to permit rapid and complete emulsification of the binder, without undue weakening of the cleaner, without loading the bath with undue amounts of dirt, and without the formation of a film of grease on the surface of the bath. The elements of time, temperature, alkalinity, and agitation are of the utmost importance, as a material which may clean perfectly in a strong cleaner, with sufficient time, and at a high temperature, with agitation, may not clean at all in a weak cleaner, without agitation, at lower temperatures and in too brief time. All these factors must, therefore, be taken into consideration in determining the materials and methods to be used.

In connection with cleaning problems, there has been more or less discussion, especially in recent years, of the question of the percentages of saponifiable and unsaponifiable matter in buffing compositions. In any discussion of this problem it should be borne in mind that there are many varieties of materials in each classification which are available for use in compositions, and that there are wide differences in the ease of cleaning, as well as in buffing

efficiency, depending on the specific materials used and the relative percentages. In normal times fully saponifiable materials cost at least two or three times as much per pound as the usual unsaponifiable raw materials. Aside from being lower in cost, certain unsaponifiable materials have distinct advantages in buffing for certain types of work. It is also true that certain fully saponifiable materials are very difficult to clean, whereas there are certain unsaponifiable materials which may be emulsified with comparative ease. There appears to be but one thoroughly reliable answer to the problem, and that is found in the final results arrived at under actual working conditions. It should be made clear that, in the above remarks, the writer is referring to the various raw materials used in the manufacture of buffing compositions, and not to the finished compositions themselves.

Cleaning of compositions may be brought about by mechanical, chemical or physical means, including various methods or combinations of methods such as dissolving, saponifying, emulsifying, with or without the aid of scrubbing, mechanical agitation, electricity, etc., and therefore the ease of cleaning may depend upon such factors as melting point, adhesiveness, solubility, the time rate of reaction with commercial alkalis, the rapidity and completeness of emulsification, and the degree of permanence of the resulting solution or emulsion.

Finishing Chromium Irons and Steels

For reasons outlined at the beginning of this article, the balance of this paper will be devoted to the finishing of chromium irons and steels. For a variety of reasons, this subject has been approached with considerable hesitation and reluctance. The newness and variety of the metals themselves, the scarcity of reliable information along certain lines, the natural secrecy of the methods employed in some of the most successful plants, the more or less experimental nature of the existing situation, the wide variety in the type of equipment, materials and methods employed and results obtained, all appear to indicate what appears to be right today may be proven wrong tomorrow, and one man's experience and conclusions may be quite out of harmony with another man's, due to differences in materials and working conditions.

It appears to be possible only to submit certain fundamental facts covering the nature and characteristics of the metal itself, its

present uses and applications, its advantages and disadvantages, and to outline some of the basic principles governing its fabrication and finishing. The most successful results will be obtained only by close co-operation between the manufacturers of the metal and of the equipment and materials used with the manufacturer of the finished article, together with a thorough study of all the various problems involved.

In order to avoid the confusion arising from the use of trade names and designations such as "stainless steel," "rustless iron," "KA2 metal" and other well-known terms and designations, all such metals may be described as low-carbon, high-chromium ferrous alloys, some of which, such as the so-called "18-8," also contain high percentages of nickel, and all of which have high corrosion-resisting or heat-resisting properties. These alloys also usually contain small amounts of the elements ordinarily found in steels, such as manganese, silicon, phosphorous and sulphur, and certain special products for special purposes may contain other elements such as copper, molybdenum, tungsten, etc.

The ability of chromium to confer corrosion-resisting properties on steel was discovered a century or so ago, but the first commercial use of this property appears to have been made simultaneously by Harry Brearley in England and Elwood Haynes in America. The first application of this steel in both countries was chiefly in cutlery, the formula being carbon .30, chromium 13.00%. The addition of high percentages of nickel was developed by Dr. Benno Strauss, of Germany, in a product containing approximately 18% chromium and 8% nickel. A third class of product has also been developed, containing over 16% chromium, but no nickel.

It is important to understand that in a series of low-carbon steels, with chromium ranging from zero to, say, 30%, there is a very marked change in characteristics at about 15%. The only properties which are practically continuous are the resistance to corrosion and to heat, which increase with the Cr. content. In other respects, the steels with less than 14% Cr. are entirely unrelated to the steels with over 16%, the range between 14 and 16 being a sort of transition zone. The low-chromium group have very different qualities and are suitable for entirely different uses from those of the high chromium group. It is therefore possible to classify all of these metals in three distinct groups, namely, the low chromium, high chromium, and chrome-nickel groups, due allowance being

made, of course, for some differences in exact properties due to minor variations in composition and in methods of manufacture.

All such alloys are manufactured by the electric furnace process, either by the reduction of chromium ores simultaneously with the melting of the steel, or by the addition of low-carbon ferrochromium. The method of manufacture of sheets, strip, bars, etc., from billets is similar to standard steel practice, except that more operations are necessary, greater care must be exercised, especially in the removal of scale and the prevention of impurities, more frequent and careful annealing is required, and special pickling processes have been necessary to remove the scale and leave the surface in better condition for finishing. The production of uniform chromium steels of the desired quality therefore demands better methods and more accurate control, and involves much more expense, than that of ordinary steels.

Certain precautions taken by the manufacturers are of interest to the users of this metal. Freedom from scale being absolutely essential to high corrosion-resisting qualities, frequent pickling is necessary; in fact, it must follow every annealing operation and every hot-rolling operation, to avoid the inclusion of particles of scale in succeeding operations. Frequent annealing is necessary to relieve the stresses and strains, promote ductility, and soften the types which have a strong tendency to work-harden in process.

For the same reasons, it is absolutely necessary to remove every particle of scale or other impurity by careful polishing of these metals in the finishing process, if a bright finish is to be produced, free from corrosion or staining in use; and, while annealing is seldom practised in the finishing plant, undue strains and stresses must be avoided by proper design of dies and proper drawing, forming, machining and other fabricating methods. Such strains may cause structural weakness, or, what is equally important, may result in undue difficulties in finishing.

Cold-rolling operations at the mills, especially in finishing strip steel, contribute materially toward producing a smooth, uniform, even surface, with comparative freedom from the well-known pits which are so difficult to remove in polishing and buffing operations. The average character of surface now being shipped is far superior in these respects to the material supplied a few years ago, with resulting ease and improved quality in finishing.

Certain steel mills are also prepared to supply sheets, strip, etc., in a semi-finished or finished condition, such as ground and polished on one side or both sides, ground, polished and buffed on one side or both sides, or even buffed to a so-called mirror finish. In cases where the metal is to be used without any appreciable amount of fabrication, and where careful handling in transit can be assured, such purchases may be advisable; however, if any appreciable amount of work is to be done on it, such a purchase cannot be recommended, as it is entirely probable that dents, scratches or other injuries will be inflicted on the surface, either in transit, handling, or working, and the damages so inflicted will require just about as much work to remove as would be necessary in doing the entire finishing. The present tendency is distinctly toward the performance of all polishing and buffing operations in the customer's plant after fabrication.

The selection of the right steel, with the proper type of surface, is of the utmost importance. The necessary information is obtainable from the manufacturer and is outside the scope of this paper; but it is essential to realize that there are wide differences between the various classes and specific products in all the important qualities, such as ductility, machineability, price, toughness, hardness, resistance to heat and corrosion, response or lack of response to heat treatment, and methods of working, drawing, forming and finishing. In general it may be said that, since the high-chromium group and the nickel-chromium group cannot be hardened, it is standard practice to use low-chromium alloys wherever a non-tarnishable surface is required on hardened products such as cutlery, springs, and parts subject to mechanical wear. The high-chromium alloys, because of their high corrosion resistance and comparatively moderate price, are used for a wide variety of purpose; and the nickel-chrome alloys are employed where maximum ductility is essential for ease and economy in hot or cold drawing, stamping, forging, etc., or where a non-magnetic steel is required.

There is a price differential of 9c or less per pound in favor of the chromium steels as compared with the nickel-chromium, although, of course, that differential will vary more or less with the type of steel. Strip steel in the usual gauges is selling on the present market at approximately 30 cents base for the chrome steels as against 9c per pound higher for the nickel-chrome. This refers to the unpolished material. The cost of fabricating and finishing of

various parts varies so widely that no worthwhile information seems to be available. The highest cost per unit is undoubtedly in the cutlery industry, first, because the material is always finished in the hardened state; and second, because the most perfect type of finish is required. The lowest cost of production is probably found in the chrome-nickel alloys, because of its comparative softness and ductility.

Assuming the purchase of the best steel for the job, in the best practical condition, and of uniform and proper quality, the first consideration is to insure careful handling in transit and in the plant, to avoid those unnecessary scratches, mars, etc., which are so extremely difficult and expensive to remove in polishing. The next element, in the case of a stamping, is the proper design, construction and operation of the dies. Too much emphasis cannot be placed on this point, because ordinary methods employed on other metals will cause endless trouble when applied here. Greater strength is required, higher pressures, more accurate tolerances, shallower draws, and greater attention to cleanliness. Chromium-plated dies are often very advantageous, and dirt and metallic particles must at all times be eliminated. Consultation with the steel maker seems to be essential in connection with the problem of dies, to avoid undue damages to the parts and heavy scrap losses.

Aside from the obvious damages which may be done by poor die practice, another effect may occur which is not so obvious. This is the so-called "orange peel" surface, caused by undue strains and stresses which open up the pores of the metal, creating a coarse condition of a portion of the surface which is extremly hard and difficult to polish or buff. Of course, such conditions may arise, even under proper die practice, if the original sheet or strip was of uneven strength or thickness, or hardness or condition of the surface. Other operations, such as cold upsetting, etc., may set up undue strains which will create the "orange peel" surface so often the cause of subsequent serious difficulties.

The problem of planning the sequence of finishing operations now presents itself. This will be determined largely by permissible cost and character of finish required. Finishing may be performed by anywhere from one to half a dozen operations, but it should be realized that very frequently it is cheaper in the long run to employ two or three operations than it would be to employ one operation only.

Certain characteristics of chromium iron alloys should always be kept in mind in connection with finishing them. First, they have a high coefficient of friction and low heat conductivity, with the result that local overheating may easily take place at the area or point of contact, with consequent distortion or discoloration; second, they are hard, tough metals, with low ductility, and the surface of the metal cannot be worked and spread easily as is the case with copper, brass, etc.; third, scratches caused by wild grains, improper setting up, or truing or balancing of polishing wheels, by too hard wheels, excessive pressure, improper lubrication or careless workmanship in polishing, will result in much extra time and labor in buffing.

The demand for low costs is such at the present time that there is considerable insistence on finishing these alloys in one operation —that of buffing. It is very doubtful whether this constitutes real economy. The surface of the steel as it comes to the finishing department seldom responds readily to buffing; whereas, even on one polishing operation, such as with a 180 or 200 abrasive, using grease, prepares the surface for much more efficient buffing. The buff then has lines to work on rather than the rough, pitted surface, and it will perform much better on such a surface, which appears to have been opened up and made receptive to finishing, much more so than the pickled and cold rolled condition as received from the mill. True enough, it may be possible to do the work in one operation, but it may not be economy to do so.

The sequence of operations on sheets at the mills may start with 80 dry, then 80 grease; but better practice seems to be to start with 120 dry, then 120 grease, 150 grease, and perhaps 180 grease. Artificial abrasives are generally recommended for the polishing operations up to the final polish of about 220 or 240, which may be a Turkish emery for the sake of the better finish. The abrasives must be carefully graded, free from oversize; brittle enough to break before undue galling of the pits, but not too brittle for efficient polishing. The polishing wheel should be soft, should operate at not over 7000 peripheral feet per minute, and must be carefully prepared, trued and balanced. Moderate pressures are essential, to avoid burning, as above. Good lubricants must be used, and successive operations should be conducted at an angle. Standard practice on sheet metal articles begins with as fine an abrasive as possible, at least a 150 if not 180. The first polishing may be done dry, but succeeding operations should be greased. A high grade grease is desirable for proper

lubrication and easy inspection of the work. For best quality work, the polish should be brought down to about a 220 or flour Turkish emery before buffing; but many average jobs are done by going from one polishing operation, 180 grease, direct to buffing. A final coloring operation, after the buffing, is desirable, but may not be necessary for average work.

The buffing operation is usually the most difficult and expensive. Special compositions must be used, usually composed of aluminum oxide abrasives. Buffs of the so-called "pocket" that is, radially, rectangular, or bias sewed to retain the composition. High peripheral speeds, up to 10,000 feet and over, are employed. Automatic buffing machines are standard practice wherever the shape of the article makes them possible. Automatic polishing has recently been developed successfully, but it is not as simple a problem as buffing. Final coloring operations are, of course, done at lower speeds, and by hand, with lighter pressures. For the finest finish, as on cutlery, green chrome oxide compositions appear to give best results, although white compositions, composed of aluminum oxides or similar abrasives, are also widely used for general work. These are hard, dry cakes, with little cutting quality, but capable of producing a high luster finish.

Corrosion resistance is usually determined by the salt spray test, or by exposure under the actual working conditions for which the part is intended. Corrosive effects are influenced by conditions of temperature and pressure and by the presence of impurities in the case of liquids. It is said, for instance, that whereas a 5% solution of acetic acid, pure, will attack a certain stainless alloy, the same alloy will not be in the least attacked by cider vinegar containing the same per cent of acetic acid.

As indicated before, the degree of resistance to corrosion depends upon the formula and on the condition of the surface. Most of such alloys will effectively resist moist air, sea water, fresh water, foodstuffs, mine water, steam, carbon dioxide, nitric acid, nitrous acid, hot oils, sugar, soap solutions, etc. They will not resist HCl, HF, H_2SO_4, H_2SO_3, especially when pure; they often resist weak acids because of impurities.

Much of these steels is sold on the basis of customers' specifications requiring from 24 to 48 or possibly 50 hours salt spray test on the straight chrome steels. It is claimed that the nickel-chromium steels such as the 18-8 type will stand the salt spray test indefinitely.

This refers, of course, to the pickled or polished metal as shipped from the mills, free from scale and impurities. Corrosion will start on an unpolished surface if a particle of certain materials becomes imbedded in a pit or scratch—such, for instance, as a particle of scale, iron oxide, etc. Corrosion will not start in a pit or scratch if it is clean.

Comparing the different steels, for general purposes, it is said that, in the early stages, many users went to the 18-8 type, or rather the nickel-chrome type generally, because of greater ductility. However, many are now returning the straight chromes, because of the yellowish cast of the nickel, especially where it is desired to match a chrome-plated surface as closely as possible, and because of the lower price, and because of the greater ductility of the present straight chrome steels as compared with the earlier ones.

Galvanic action may induce corrosion which would otherwise not occur. It is well known that when two metals of different potential are in contact with each other and are moistened by any corrodent capable of conducting an electric current, an electrical potential is set up between the two metals causing a current to flow from one metal to another, and greatly increasing the corrosive effect on the more electro-positive metal, depending upon the difference in potential. Chromium alloys take a position in the scale between Cd. and Co., and slightly negative, and adjacent to, iron or mild steel. The possible effect of galvanic action must always be taken into consideration in designing any apparatus or machine in which chromium irons are to be used, and such contacts of dissimilar metals must be avoided if such alloys are to reliably resist corrosion. Galvanic action will also cause rusting if some other metal becomes imbedded in a pit or scratch on the surface. However, if pits or scratches are to cause rusting, the rust will be evident within twenty-four hours. To prevent such a condition, some steel manufacturers ship their metal in an electrically passive condition.

It will thus be seen that the proper fabrication and finishing of chromium irons and steels constitutes an interesting problem; that the metal is apparently suitable for certain purposes, but of doubtful value for other applications; and that satisfactory results along any line may best be obtained by a thorough study of all the characteristics and factors involved.

For the proper finishing of these alloys, the same fundamental principles apply as should be applied to any other finishing problem.

First, a comprehensive plan should be worked out through the close co-operation of all the men responsible for results; the fact should be recognized that in this sequence of operations each operation has an effect on every succeeding operation, and the materials and methods employed throughout should be properly adapted to each other and to the whole plan of operation.

I have one other remark to make, and that is, as an outsider, observing polishing and plating conditions in plants, I think that very much greater progress could be made, more easily, more rapidly, by more confidence and co-operation between the plater and the polishing room foreman and the other men in the plant. At times we find ideal conditions, and at other times they don't seem to be quite so ideal. Just as an illustration of one or two points, I have one example to state, and then I am finished. I happened to go into a plant about two weeks ago where a certain polishing grease was used, and in talking to the plater I found that he was having difficulty with it, but he thought that the foreman in charge of polishing was very anxious to use it. In talking a little later to the polishing foreman, I found he was having some trouble in using it, but he thought that the plater was keen about it. And a little while later, in talking to the chemist, I found he thought it was a wonderful grease because his analysis in the laboratory had showed it was very high in the percentage of saponifiable matter. But along about noon everybody got together, and we tried to find out who really wanted it, and each man said that he thought that the other man liked it, and the net result was it was possible to discuss the whole problem and to use a material which was much more satisfactory throughout. I think that is, of course, not a typical case, but sometimes it does happen.

[Applause.]

BRANCH NEWS

DETROIT BRANCH

Detroit Branch A. E. S. held its regular monthly meeting October 2 at the Statler Hotel. President Jos. H. Hansjosten presiding. After the regular order of business the meeting was turned over to the Asst. Librarian, Mr. B. F. Lewis, who conducted the Question and Answer box. The following are questions asked:

Question—Should brass parts which have soldered joints be copper struck before nickel-plating?

Answer—It is common practice to copper strike in such cases.

Question—What makes a cyanide copper solution pit?

Answer—High carbonates or suspended particles in the solution.

Question—Would you recommend a young man to take up plating as a career?

Answer—Some of those who have been in the business for many years feel that the compensation now received by platers is not sufficient to encourage a young man to undertake necessary study and arduous practical training required. However, this condition exists in many, if not most, other professions, and will not be a bar to young men of the type who make their own opportunities.

Question—What is the Society (A. E. S.) doing to help revive the plating industry?

In connection with the

Electroplaters' Class

at the College of the City of New York

Dr. Pan has just revised and enlarged the test-book for the laboratory. This book contains 32

Exercises on electroplating, testing, and analysis of solutions

but is solely used by his students. Since there are many members of the A. E. S. who would join the class in New York, but could not do so on account of the distance and other reasons, he proposes to supply them with this book so that they may do whatever home study they like with it.

He charges his students $3.00 per copy for printing expenses, for the 100-page book, 6 figures and 2 charts. The charge to the members of the A. E. S. is on the same basis if they care to have the book.

The research program at Washington, sponsored by the National Society, is the biggest contribution to a revival of the plating industry that could be made at this time. When the results of this work are made public and a definite standard of values in electrodeposits is set up, the plating industry will be in a position to take a new lease on life.

Question—Is the low pH nickel solution meeting with the commercial success that the authors claim for it?

Answer—There is no refutation of claims made for the superior corrosion resistance of deposits from the low pH bath. However, it is generally believed that the high pH bath offsets this by its superior throwing power, and consequently better *average* protection of the base metal. Both types of bath may be operated at high current density. In general it may be stated that the low pH is advantageous on simple shapes where throwing power is not a factor.

Question—Is it of any value to ascertain the pH of a cleaning solution that is being used in continuous production?

Answer—It is more practical for purposes of control to determine the total alkalinity of a cleaning solution by titration.

CHAS. M. PHILLIPS, *Secretary and Treasurer.*

CLEVELAND BRANCH

The regular monthly meeting of the Cleveland Branch was held at Hotel Winton, Saturday evening, October 3, President E. Steen Thompson presiding.

The minutes of the September meeting were approved as read.

Plans for a class in the chemical analysis of the plating solutions were discussed and a committee was appointed by the Chair to investigate possible places where we could get this instruction and to have a report ready for our November meeting.

A Convention paper by Mr. O'Connor on the subject, "Barrel Rolling and Plating," was read by our Librarian and a general discussion followed.

A motion to adjourn was carried at 10 p.m

PAUL STAMM, *Secretary.*

PROVIDENCE-ATTLEBORO BRANCH

The meeting was held at the home of Mr. Chace. There was a round-table talk that lasted through the evening. Business was omitted. Mr. John Garrick, as usual, brought us a sticker, from somewhere: the problem was a belt-buckle, made from cold-rolled steel. Treatment was to: nickel, copper, and either finish in silver or gold; the plater has finished thousands of the buckles without having any trouble, until recently some of the buckles showed spots that were peeled, i.e., the nickel seemed to lift from the steel. He is doing them exactly as before and cannot understand why he has trouble.

After considerable discussion the question was left open; if any member can help on this problem, will he please write to John Garrick, 94 Robert St., Attleboro, Mass.

The next problem was: plating pewter and white-metal; whether it was necessary to use a quick-dip. Some said Yes, others said No. It was stated that some platers used a quick-dip, while others nickel-plated the goods.

The next question or problem was: Does nickel, when added to a silver bath, plate out, and does it produce a harder deposit? There was a difference of opinion on this question.

We adjourned about 11 o'clock.

JOHN ANDREWS, *Secretary.*

PHILADELPHIA BRANCH

The Philadelphia branch held its regular meeting on October 2, with President Harry Snyder presiding. After the routine business was gone through, the Banquet committee reported that the Educational meeting will start promptly at 3 p.m. on Saturday, November 21, 1931, at "ADAMS," 13th and Spring Garden Sts., and the following program has been arranged for:

"Manufacture of Photographic Records"—by R. A. Dimon, RCA-Victor Co., Camden, N. J.

"Anodic Treatment of Aluminum"—by Edwin Joyce, Philadelphia Navy Yard.

"Preparation of Steel Prior to Electroplating"—by George B. Hogaboom, Hanson-Van Winkle Munning Co., Matawan, N. J.

"Plating of Chromium at High Current Densities"—by Lieutenant A. Willink, Frankford Arsenal, Phila., Pa.

The above will be a very interesting program and well worth the time in coming a long distance to hear, and the committee knows the Philadelphia banquet fans will not be disappointed in the Meeting or the Banquet at 7 p.m., so check up on the date and be in Philly on SATURDAY, NOVEMBER 21st.

The meeting was now turned over to Dr. A. K. Graham, who gave a talk on Low pH Nickel Solutions, as follows:

DR. GRAHAM: Before entering on the subject under discussion for tonight, I want it understood that what I have to say of course is the results of others' work, largely that of the research department of the General Motors Company, and the most that I can do is to offer what has been reported in the literature or at the meetings where this development has been discussed.

It might be interesting, just for a few moments, to think back and trace the development of nickel-plating in the first solutions with the double sulphate, ammonia and nickel, with additions of boric acid and, later, with chlorides. They were solutions which were operated at room temperature; because of the limited solubility of double nickel sulphate, the metal content of the solution was low, not over 1.8 ounces per gallon or thereabouts and, conse-

quently, the rate of plating from those solutions was limited because small current densities had to be used and the actual time required to plate a different thickness was much greater than from the later solutions which have been developed.

Then we had a development of the single nickel salt solution where the biggest difference was in the concentration of nickel in the bath and because of the fact that you can dissolve considerably more single salt per gallon of water you could get more nickel in. In addition to the fact that the single salts contain about 22 per cent nickel where the double contain about 14.7. With the single salt solution we had heavier plating, we had more rapid barrel plating and then Dr. Watts made the additional improvement of operating the single salt bath at high temperatures bringing in the so-called hot nickel solution. Now, by raising the temperature, they increased still further the amount of nickel salts which they could dissolve, thus increasing the metal concentration to a still higher value and permitting higher current densities and, consequently, more rapid depression and, as a result, heavier deposits in shorter time, as a rule.

Along with that development has grown the demand for heavier nickel in order to give adequate protection and a sufficiently long life and service for the article being plated. The automobile industry, of course, has given the greatest impetus to that development. The General Motors Company stumbled on to the high acid or low pH nickel solution accidentally, and when they actually attempted to check the very satisfactory results in one of their plants they were somewhat surprised to find the pH down around 2 and to find that satisfactory plates were being obtained at that low pH, and very rapid plating with a very satisfactory deposit. One of the limitations of the hot nickel bath, at high pH, that is the bath of the Watts type as we had operated prior to this new development of low pH, was that if you wanted to get a heavy deposit of the nickel—and that is what is being demanded today—you wanted to get it as rapidly as possible in order to get a maximum production through a given tank and yet you couldn't go too high a current density because at the high pH the solution was sufficiently alkaline, so that there was a tendency for the deposit to become rough. It would burn if you got too high, but the roughness was the chief difficulty and even the possibility of cracking of the deposit at the edges when you went to the heavier deposits.

That can better be appreciated when you realize that the buffer speaks of a soft deposit of nickel as one which is easily buffed. It really doesn't mean softness in terms of units of hardness, but it means that the plate is sufficiently smooth so that with the least amount of effort he can produce a mirror finish on that article. If, on the other hand, the volume is very rough and uneven; then he has to put additional labor on it in order to get the high spots off and get rid of the valleys and give you a finish. With the low pH nickel solution it is claimed that you can get in heavy deposits of nickel, smoother deposits, freer from the tendency to become rough and to peel and in about, well, I would say in less time than it takes in the ordinary hot solution at high pH, primarily because you can use a higher current density during the time you are plating and still maintain a satisfactory character of deposit.

The recommendations that have been made have been chiefly for heavy deposits, but the ability to get this improved plate in a shorter time at higher current densities is a direct result of an increase in the permissible plating range, the current density that is possible as a result of the use of low pHs in nickel solutions.

Now, the bath that they used was the same hot nickel composition that Watts recommended, running around 250 grams per liter or approximately—let me see—about four or five ounces of metal per gallon. And with that they found that in the low pH they could get a much greater increase in the permissible current that you could use. Now if we will take pH as 1, at a temperature of 135 degrees for a five minute deposit—and this is for a light deposit—you can use as high as 170 amps. per square foot. That is the maximum that you can possibly have. Now if you have a plate of any dimension, there is a variation in the current density over that surface and we know that, at the corners particularly, you have your maximum current and somewheres in the center you have your minimum current per unit area, because the current does not distribute itself uniformly over every square inch of surface. Therefore, we are interested in what the smallest value is and what the maximum value is because between those two values we get satisfactory plates. If we have a value of current for the entire piece which is going to give us too high a value on the high point of high current density, it is going to burn or become rough or blister or peel. Consequently, we want to establish, to start with, what the plating limits are, so that we can operate within

them. 170 is the maximum that you can possibly have, but that is way above what we ordinarily associate with hot nickel and, consequently, you see it gives you an idea as to the current that you can use that you wouldn't have otherwise.

Now for comparison with the other pHs, a pH2 would permit you to have a maximum say of 95 amps.; a pH of 5 a value of 30 amps. per square foot; a pH of 6, a value of 16 amps. per square foot. In other words, by lowering the pH from 5 or 5.8, down to these new values, 170 and 95, you can plate at much higher current densities without having any of the difficulties ordinarily associated with high current density.

Now that, of course, also varies with the temperature of your bath. I think the plating of chromium was the first type of commercial plating that emphasized the relationship between variation in permissible currents that you could use and temperature, and you know that in chromium plating you can't get any results unless you fix one and vary the other, and there is a very definite relationship between the temperature and the current densities that you could use. And here again we find that the same relationship holds.

Now if we come down to 120 degrees Fahrenheit, the maximum would have to be 135; 70 for pH of 2; 27 for pH of 5 and about 16 again in the pH of 6, and so on. At 105 degrees Fahrenheit; 105 also under pH of 1; 58 amps. for pH of 2; 26 under pH 5; 16 under pH of 6.

Again, at 90 degrees F.; 70 under pH of 1; 45 with a pH of 2; 25 with pH of 5 and pH 6.

Now with a study on panels of definite dimensions at different temperatures and different pHs, the General Motors made their first report on it and they generalized and said that in the pH of 6 the maximum current at any point on the work would have to be under the 16 amperes per square foot, because, if you went beyond that point you would have peeling or rough deposits; and it's around about 27 or 30 for pH 5; on the other hand, at these lower pHs, the current is much higher that you are permitted to use.

Now that was for a light deposit, a five minute deposit. Now if you are going to plate for a commercial thickness of about five ten-thousandths of an inch or more, then you have to cut these currents down somewhat because they are a little too high for the heavier deposits. And beside these current values I will write

what the corresponding values would be for the heavier type of deposit.

Temp. F.	pH 1	pH 2	pH 5	pH 6
170 — 150	170	95 — 85	30 — 50	16
135 — 115	120	70 — 68	27 — 44	16
105 — 85	105	58 — 55	26 — 35	6
95 — 85	70	45 — 45	25 — 28	6

And the interesting thing with that pH 6 at 135 degrees, the maximum for five ten-thousandths would be about five amperes per square foot, whereas at 90 degrees you can't get a satisfactory deposit even by lowering the current down to a negligible value. so that it shows that with the pH that was ordinarily used and which we were almost convinced was the necessary value of pH for nickel-plating, somewheres around 5.6 to 5.8 for the hot nickel type of solution, we were operating in a range where the problem of getting a very heavy deposit that was going to be satisfactory was much more difficult because of the fact that you were limited to the current density that you could use.

On the other hand, when you lower your pH to the values of 1 or 2 you have wide limits of current and consequently more latitude.

Now so far as the solution itself is concerned, the original work was done on a solution containing nickel salt—and this is the single nickel salts, 250 grams per liter—which corresponds to about 7 ounces per gallon of metal. I think I said four or five, but about 7 ounces per gallon of metal. If I take a pH of 6, with that concentration the change in pH during the operation of the bath is relatively slow unless you had drag over of alkaline from either cyanide copper prior to your nickel or plating solutions and so on. Your solution didn't tend to change the pH very rapidly with the high pH type of solution, so that we could say—I'll call this here Delta pH, by which I mean the tendency for pH to change was very slow for that type of bath. With the same concentration, at a pH of 2, the tendency is to change much more rapidly. That imposes a problem more difficult on the plater, necessitating him to control pH because it will change more rapidly with this lower value of pH during the plating. That is partly due to the fact that in plating you have higher current densities, but there is an additional factor that enters in here, the act that this pH changes more rapidly and therefore might be more difficult to control and that is with

the other type of bath—and I was just using that, not that your bath would necessarily be operated ordinarily at 6. As I have indicated before, the hot nickels were ordinarily operated at around 5.6, and I am just using 6 as a round number to make a comparison between the high and low pH baths—but with this slow type of bath, high pH, the variation in pH was usually about plus or minus one-tenth, when we first started out. We have decided that the bath should be kept within those close limits. In other words, if we had a value of 6, the figure at which you were going to operate the bath, if it got below 5.9 we would adjust it and if it got above 6.1 we would adjust it. Later on we got to realize that that control in most cases wasn't so necessary and could probably let it vary probably as much as plus or minus two-tenths of a pH. But they were the limits that we fixed for the control, even though it did vary slowly. Now with the slow pH bath it varies with this low pH rapidly, but it is possible for it to vary within much wider limits without very detrimental effect.

So the permissible variation might be as much as plus or minus 1.0 or under. So that your solution could vary ten times as much here without necessitating immediate attention even though it did change more rapidly than the bath above it.

Now the chloride and the boric acid in the bath are the same as in the high pH bath. The anode corrosion with the high pH bath offered considerable difficulty. Two, three, four and five years ago there was a lot of agitation about anodes and anode corrosion. It is still with us, but it seemed to break out then as a new problem with the development of the old heat-treated anodes and the depolarized type, and with any one of those types you still had some problem in the way of corrosion. The difficulty was that your bath in some cases would not keep itself up in nickel, because the number of pieces that you could put in there, that you could put in from end to end along the edge of the tank on the anode rods, wouldn't give you enough active area so that you could take metal in from them as rapidly as was plated out and even if that anode deficiency was measured and found to be slightly under 100 per cent, the tendency was that nickel would detract out at any rate in the operation of your bath, so that your nickel content would decrease and you had to make it up with salts. Now with this low pH bath, the anode deficiencies, of course, according to Faraday's Law, can't be over 100 per cent, but it is good, the type of

anode disintegration is good, but at the same time, your cathode efficiency is going to influence the result on the maintenance of the nickel content of your bath in this way—the cathode efficiency here might be about 95 per cent, with the high pH bath; with the low it would be around 75 per cent. That means that even if the anode efficiency in each case were 100 per cent, that you're plating more metal out here (at 95) per unit of current, than you are here (at 75), and the tendency would be for this solution (250 grams) with the dragout, to decrease in metal, where this one (lower 250 solution) would more likely stay constant, and that was borne out by the experience of the people operating these solutions. The metal content, if anything, will build up because your cathode efficiency is less than 100 per cent and your anode efficiency is pretty close to 100—you are plating out less than you are putting in.

To overcome that tendency to build up, they put in some insoluble anodes, lead anodes. I am not prepared to say that that is the best thing. It undoubtedly reduced the amount of metal going in at the anode and tended to equalize the metal concentration of the bath. Furthermore, it is significant that with this low type of pH bath the metal content of the solution is maintained from the anodes which is more economical than that in salts as required up here. Now, to summarize what I said about this maintenance of nickel content, liquid metal content, in the solution, the anode low pH in the bath is of better character than it is in the high pH bath and even if the efficiencies are about the same, or close to the 100 per cent, even if they are about the same, the fact that the cathode efficiencies are different means that in this bath (95 per cent) you are plating out about as rapidly or slightly less so than you are taking it from your anode, and added to that depletion of metal you have your dragout. The net result is that your metal content decreases. You've got to make it up with salts.

With a low pH bath, assuming a 100 per cent anode efficiency, your cathode efficiency is much lower than it is here; that means you are plating out less than you are taking in and that counterbalances the dragout so that in many cases your nickel builds up, and to cut down that, they use some insoluble anode. Of course, if your dragout is very large you might balance out and stay con-

stant. The big economical feature is that the metal comes from the anodes in this bath; you don't have to add salts.

Now the additional feature is that from an economical point of view the time for producing a .001-inch deposit in a bath of a pH of about 6, assuming that the character of the deposit is satisfactory, in other words that you are plating a heavy deposit at that thickness that is not going to peel and is not going to rough, even if that is possible it is going to take you about 150 minutes; whereas, with the low pH bath for the same thickness, you are quite certain that the character of your deposit is going to be satisfactory. You are plating at a higher current density and it is possible to do it in about 15 minutes. So that from the point of view of time, it has attractive possibilities.

Now, as to the character of the deposit, the first results seem to indicate that with a low pH bath, that gave bad pitting but after a period of operation there was not any more pitting and associated with the ordinary hot type of bath even at the higher pH, after you got over your initial difficulty. Very severe pitting at first; after you got over that the bath seemed to season itself and then so far as pitting was concerned there was no difference between the ordinary hot nickel bath, high pH and that of low pH, but there is an advantage, as I have emphasized before, in the ability to plate a heavy deposit and have it satisfactory with regard to roughness and peeling, which you can't have as definitely with the high pH bath; furthermore, the corrosion resistance of the low pH bath appears to be better.

With respect to corrosion, the bottom appears to be better. Now that was attributed to different physical characteristics of the article itself. Probably denser; its crystalline structure was probably finer and covers up the pores of the base metal more effectively.

Another feature is that operating with the low pH bath, where you are going to flash or plate chromium on top of the nickel, the tendency for the chromium to peel is reported to be much better, rather the tendency for it to peel has been reported to have been eliminated, to a large extent with a low pH bath. I can believe that when an article is taken from that nickel bath without any immediate polishing and put in chromium, or even if you polish it, I believe it because one of the things which we know will cause your chromium to lift and take the nickel with it is an alkaline

film under the nickel. Now it is very easy to see that if you have any alkali in it at all on your base metal, when you take it into your nickel-plating, that the opportunity of neutralizing that alkalinity, even before the metal is covered with nickel, is greater in a more acid bath than in the more alkaline bath, and the result would be that any slight alkaline film going over into that bath would at least to some extent be neutralized by the greater acidity of the bath prior to the complete covering of the nickel.

Now as to the actual physical hardness of the nickel from the two baths, there is very little difference. That brings up the point that I referred to before, that the buffer thinks of hardness in terms of whether a thing is easier or more difficult to buff and does not necessarily mean the relative hardness according to some scale of hardness. Furthermore, the scratch-hardness test which was the one used here and the one most applicable, is one that is subject to quite some variation in the actual technic of the test itself and the numbers can't be regarded as being too absolute, but the average of a series of tests on hardness of the high and low pH bath show there was practically little difference at a given temperature. On the other hand, hardness does vary with temperature but we know that is so with any product.

To illustrate the variation of hardness with temperature, I have chosen these values of temperature in degrees Fahrenheit. At 100, and 175, at a pH of 5 in both cases, and the hardness by the scratch-hardness test—at 100—6.54; as against 9.65 with the higher temperature. Now if we go to a pH of 2, at 100 degrees the value is 5.64, and at 175 the value is 10.61. Merely showing that the hardness does vary with the temperature but as I stated before, it does not necessarily vary with pH at one temperature. That is, within the limits of 2 to 5, under which they were tested.

Now to summarize: You can see from the data that has been presented that there are a number of features connected with this new development, the low pH bath which make it attractive. Wider plating ranges so far as permissible current is concerned so that at the recesses and at the exposed edges of your work you can have a greater difference in local current density and still get a satisfactory deposit; more rapid plating for the same thickness —which is an economic feature; your anode behavior is somewhat improved although I won't make any extravagant claims as to the benefits of one over the other. The maintenance of the bath

itself, as far as nickel is concerned, is improved, the metal coming from the anode. The control of the pH is about the same so far as ease of control is concerned. The character of the deposit is improved, particularly when you go to thick deposits of nickel.

Now some additional work was done at higher concentrations. 400 grams per liter corresponded to 9 ounces per gallon, at pH of 6 and pH of 2, and at the higher concentration it was found that you could get good deposits above 90 degrees F., anywheres above there, anywheres between a pH—well, I wouldn't say anywhere between—but your limits of pH were wider, so that it was possible to choose pHs varying from let us say 1 and 5; whereas with the lower concentration we are really comparing these two, not the low pH and the high pH, but with the low pH acid bath with the more concentrated bath, the permissible variation of pH was greater. It was said, principally, that with these low pHs baths, if the pH went higher than 3 or went up around 3 you began to get real occurrences of severe pitting and it was difficult to handle. So that the practice was to operate somewhere around 2 or 2.5; in other words, it could vary down to 1 or up to 3, but couldn't go above without severe pitting. However, by increasing the concentration of the bath it was found that you could operate within wider limits of pH in your bath and still get satisfactory deposits, and there is another feature about the high concentration and that is this, that in your mixture of throwing power, the high concentration bath would be giving you better throwing power than low concentration. Now ordinarily, with the hot nickel solution, for these rapid plating nickel baths, the throwing power is not exceptionally good, it is not the best type of solution for throwing power, so that it is interesting to know that you can change that and modify it, even retaining the benefits of the low pH by increasing the nickel concentration of your bath.

Now so far as your chemical control of your solution itself is concerned, there is no difference. I say there is no difference, but I am assuming that you are thinking about chemical control the same way I am. Your nickel content operates the same, your chlorine is determined in the same way, the pH is determined colorimetrically. You can get color standards that take you down to the lower values of pH, or you can operate with the (Quinn) hydro-electrode, as some of you do. If you are going to go to the titration method of controlling your acidity, which I knew some of you are acquainted

with because we discussed it in school here, there is a slight modification. I won't go into the details of it, it's not difficult at all, but the thing is it has been suggested by Dr Payne of New York University that the method of titration is the most desirable method of controlling the pH of these low pH nickel solutions. And the advantages that he claimed are the same advantages that have been claimed for the other method by others all along and that is this, that when you run a titration, with methyl red as the indicator, you determine the amount of chemical, acid or alkali, that you have to add to that solution to bring it back to a given pH. The only thing that is required is that you make your titration on that solution in which the nickel and the chlorine and boric acid are kept constant.

Now if you control your nickel-chlorine-boric acid in the ordinary way I assume you have some definite procedure of adding a certain amount to take care of dragout; the chlorine and nickel are the chief constituents; if they are maintained at a fixed concentration, then the sizing up by titration will tell you automatically how much chemical you must add to bring that bath to a given pH, and it is undoubtedly the best way in controlling the pH of this type of solution.

Now I don't know that I have anything more to say. I might mention this, that these baths have been used for heavy deposits chiefly. They have not been used in barrel plating; they have been used in conveyors, automatic conveyors, things of that kind; they have not proven satisfactory on die castings—it is readily understood why. We ordinarily recommend a higher pH for die castings, over toward the alkaline side as a rule—I say alkaline side, 6 or above, in order to decrease the tendency for the deposit to peel or for nickel to deposit by immersion before the current has a chance to plate, so that you see as you increase the acidity or lower the pH you are producing conditions which are least satisfactory for plating die castings. And I think that that will conclude my remarks, unless there is some discussion.

Question: How about still tank plating?

DR. GRAHAM: Perfectly all right in still tank plating.

Question: No agitation necessary?

DR. GRAHAM: No, of course the same thing holds true as in any type of solution, that your permissible current density would vary with whether you had agitation or whether you didn't. If you

are plating in a still tank your current density would have to be lower than if you are in a conveyor with a certain amount of agitation.

Question: Would the addition of hydrogen-peroxide help to prevent pitting in that low pH solution?

DR. GRAHAM: Yes, the antidotes that were used on the old high pH hot nickel solutions have been used in this work and the only recommendations that have been made—and I think that I would subscribe to them too—have been that the hydrogen-peroxide is a better means of control than the sodium perborate, for the simple reason that when you add hydrogen-peroxide you are not adding alkali that will change your pH.

Question: Isn't it slightly acid?

DR. GRAHAM: Yes, in order to make it stable, but that is changing the pH in a direction that is not dangerous.

Question: I had occasion to be in Detroit about a year and a half ago when the Pontiac plant made this first try-out. Mr. Phillips out there pointed out the fact that they put their copper deposit on, then their nickel and then they buffed their nickel. It is quite ductile and they buffed it and they have little difficulty in getting a high polish and then go right into the chromium. In the other General Motors plant they were buffing their copper.

DR. GRAHAM: Well, that is directly associated with the explanation that he gave. They are not my words but his explanation and we have to repeat it if you want to be correct. If you have a base metal and you put an undercoat on there, it could be copper, nickel or nickel, copper, nickel. And then, if you are going to buff it, if this outer surface, before you buff it, is very smooth, it takes little effort to bring it up to a lustre. On the other hand if you have some hills and valleys, looking at it under a microscope, by the time you start cutting through here to get it down to make it smooth to get a lustre, you are liable to have a nodule pull out of here, pull out a rough grain or crystal of the metal and expose your base metal, and particularly on the edges because the tendency there to be rough would be greater. Now they bear on the wheel harder because it's rougher on the edges and consequently cut through.

Question: Doesn't boric acid help to maintain a softer solution, softer nickel deposit?

DR. GRAHAM: The only reason I hesitate to answer is because it is not very clear in my mind what we mean sometimes when you say "soft" nickel. Do you mean soft?

Question: Yes, brittle; in other words, take a deposit that you can bend up when it breaks. Take another deposit, one that will likely be more brittle.

DR. GRAHAM: Yes, that is attributed to the buffer action of boric acid and in that sense boric acid usually permits you to control your pH at a value of least variation; where, if it were to vary without any buffer action at all you might get it so acid that your tendency to peel would be greater. However, when you come down to the lower pH solutions, they are very acid and the buffing effect of boric acid is up around 5.8; in other words, the point where you can observe this buffer action is about the pH that was ordinarily recommended for nickel-plating, prior to this development. Now with this solution, where your pH is down around 2, boric acid is of little value or no value as a buffer. I am not prepared to say of what value it is in that solution, but it certainly isn't acting as a buffer in that solution because it is so acid at any rate.

Question: Some years ago I heard a plater ask why boric acid was put into nickel at all. Wanted to know if it wasn't to make it whiter or softer, and I couldn't tell him, but I had good nickel and I don't know what it's for. I use it.

DR. GRAHAM: Of course when we are talking about the benefits of boric acid we are talking about the high pH solution and not the low. Suppose you are running work in a barrel and the stuff that you load in there you can put through your clean solution in a basket to dump it into your barrel and some of those articles that you have in the basket like that carry over quite a little alkali; it's pretty difficult to get your mix waters clean too. Well then there is a tendency for your solution to go alkaline, due to the dragover being greater. Now if your solution becomes alkaline enough, your deposit becomes progressively darker and in work of that kind it is customary to add boric acid even more regularly and to pay more attention to it than in ordinary plating and people that use it there, use it because they say it gives them a white nickel. What it actually does is to buff their solution so that it is more difficult for the pH to go up when the alkaline is carried over and that means your nickel is whiter.

Question: Dr. Graham, you say when the buffer talks about soft nickel he doesn't mean in the hardness of the nickel. Well, you take a buffer and he will tell you whether your nickel is brittle or whether it is soft. By that I mean you take a piece of work which has a press operation after it is finished; well, if your nickel is brittle it is going to crack, that's what the buffer means when he says "hard nickel." When he gets the rough stuff he says "cinders"; that's what he means by that.

DR. GRAHAM: Well, I answered this question about boric acid by saying that there is a doubt in my mind as to just what he means by "soft." This explanation has to do with heavy type of deposits on automobile work from the hot nickel type of solution. Now let us take as another illustration, to answer your question, the difference in buffing effort required for spring brass and on dead soft brass annealed, or copper, either one. Your dead soft metal will pull and drag on to the wheel. It's like trying to put a finish on lead, it's a soft metal and you can't bring it up to the lustre that you can on hard spring stock brass or copper. Now there is a difference in hardness or softness there that the buffer can recognize and when he says a piece of metal is soft because it flows under the wheel, he means in terms of softness and hardness. But it is quite a different condition from this.

Question: Well, the boric acid has a tendency, if you are running a nickel solution and buffing your work and there is a press operation afterward, or two press operations, your boric acid has a tendency to carry it through. I have found that. That's about the only way that they figure your softness on nickel.

DR. GRAHAM: Well, in the high pH solutions there is undoubtedly a number of benefits from boric acid; whether they are directly attributed to the buffer action or not I am not prepared to say. In the low pH there is some question as to what value it has.

Question: Is there any explanation there in that table—I notice on pH of 1 you have a decrease, when you go to the heavy deposit, that is, in the current density from pH 2 you have likewise but in the pH 5 you have an increase. That is all the way down the temperature range.

DR. GRAHAM: If you'll just pardon me a minute I'll look at the original curves, maybe I can find the explanation there, because I think I copied that correctly on the blackboard. Now I have copied it correctly as to values here; I have copied the correct

values here for the heavy deposits, for pH 5. There is a graph right here which is drawn and I'll illustrate it this way. This is amperes per square foot and this is temperature, degrees Fahrenheit, and at 90 the corresponding current is about 28 and the curve goes up from there in this manner. Now, with the light deposit, pH at 5 goes almost directly up from 25 amperes; in other words for the light deposit the curve goes up like this. Now that's the curves that they are drawn on. So that according to that, you see this slopes over slowly. Now they are the two curves. The only explanation I can offer is this, the actual location of this one is subject to some variation one way or another. They just plated panels and tried to strike a point which would represent their average results and I think these things are probably pretty close together at that pH. You see there is not an awful lot of difference between these under pH 6 numerically and that is probably the explanation.

Question: Doctor, what about the amount of chloride in that bath; how do the various amounts of chlorine affect it?

DR. GRAHAM: Apparently they run the same as the ordinary Watts bath and the ordinary Watts bath originally called for three, or rather two, of nickel chloride, two ounces per gallon, and then the later developments for the ordinary hot nickel at high pH were up to 4 of chloride, not all added as ammonia chloride, but this work was done with, as I recall, two ounces of chloride in the bath and 4 of boric acid. I don't believe the chloride variation would produce any more difference here or give you any greater effect than in the ordinary high pH hot nickel type.

Question: Doctor, what would be the covering or throwing power at the high temperatures, in the low pH?

DR. GRAHAM: Well, of course the covering power is good, because of the fact that you've got wide variations in current. Now these are not exactly the shape of the curves but they are the relative positions. With a pH of 1 — 1, 2, 3, 4, 5; and these don't come down as straight as that, and this other one, four, goes off at a little more of an angle like that and then these others slope in more. Now in their data, the way they present it they tell you that at any one of these pHs, at any value of temperature and current which will place you to the left of one of these lines, you can get a satisfactorily heavy deposit of nickel. To the right it will be burnt, rough and peeled at the edges, in other words you get in

the area of unsatisfactory deposits. Now if we take the pH of 2 it means that any value of current and temperature on this (to the left of the line) anywhere at all over here, we can get a satisfactory deposit, but the minute we get at a value on this side (right side of the line) of that line we get into the area of unsatisfactory deposits. Now if we compare the area on this (the left side) side of pH2 with that of a pH of 5 which is limited to this space here, we see what a marked improvement there is in the operating range of both current density and temperature for a pH of 2 as compared with a pH of 5, and then when we increase the concentration of nickel, this pH of 5 assumes another position, off like that, at the higher concentration of nickel, showing that by increasing your concentration you get a possible variation in current density and satisfactory plates, very closely approximating the lower pH values that you had before. That, of course, is with the higher concentration of bath. I pointed out over there that the permissible pH variation was one to five when you had concentration of 9 ounces per gallon of metal. Does that answer that question?

Yes, sir.

[Applause]

Rising vote of thanks asked by the Chairman for Dr. Graham's talk. The Educational committee then reported that the next meeting will be held at the Harrison Laboratory, U. of P., November 6, at which time they will have a motion picture entitled, "From Mine to Consumer," by the American Brass Co., who will also supply a speaker to answer your questions on Metals.

The meeting then adjourned, time 11 p.m.

Jos. E. Underwood, *Secretary.*

CHICAGO BRANCH

The regular monthly meeting of the Chicago Branch, A. E. S., was held October 10, 1931, at the Atlantic Hotel.

Meeting was called to order with President J. C. Kretschmer and all officers present.

This is the time of the year when we begin to think about the education and pleasures that take place during the long winter evenings. Therefore President J. C. Kretschmer appointed Mr. H. A. Gilbertson chairman to investigate the possibilities of holding a chemistry class. Let's make this class a larger enrollment than the last one. Also Mr. C. E. Clindenen chairman to look into the possibilities of holding a banquet and educational session or some other form of entertainment, both to report at the November 14 meeting.

One application was received for membership, Mr. Fred A. Schneider of Crane Co.

The meeting was then turned over to our librarian, O. E. Servis, who found the following questions in the box:

Question—Which affords the best protection, electro lead plate or hot dip lead plate?

Answer—Uniformity of deposit is done by electroplating.

Question—Is it more desirable to use copper anodes in a brass sol. than brass anodes?

Answer—This question caused some discussion. You can control cyanide easily with copper anodes, matter of preference.

Question—Can nickel be deposited over a coat of cadmium in which mercury has been used as a brightener? This is a standard nickel sol.

Answer—A nickel solution with a high sodium sulphate content was recommended, and keep work from oxidation.

BOSTON BRANCH

Boston Branch met Thursday, the first, at the American House with President Gale in the chair.

After the reading of communications and bills, a motion was made that a committee be appointed to arrange for another chemistry class this coming winter, to start about December 1. The following were appointed: Chairman, Charles O. Hardy, Albert Beckett and Andrew W. Garrett, to make all arrangements.

One application was received for membership.

Our librarian, Mr. Mackie, will arrange different talks for the coming winter and will have a question box for the members who have questions that will help them in their troubles.

Boston Branch expects a great year with the chemistry class, which will be larger than last year.

Discussions took place for more than an hour, after which the meeting adjourned at 10:30 p.m.

Yours,

A. W. GARRETT, *Secretary.*

MILWAUKEE BRANCH

The regular meeting was held Thursday evening, October 8, 1931. It has been our custom to have a booster meeting and smoker in October. These meetings are generally well attended, as matters pertaining to the general welfare of the society are brought up at this meeting. This meeting was not well attended; seems as if the members are still on their vacations. Affairs

of the Society in general were discussed, also reports of the work being done by the research associates. The question of who is having the most benefit of this research was thoroughly discussed. The opinion was that the manufacturer is getting the major part of the benefits of this work, but the manufacturer does not contribute in proportion to the benefits he gets. This seems to be the case when the Supreme Society recommends a voluntary contribution of $2.00 per member per year to help defray the expense of the research associate work. This matter brought out heated arguments, and when brought to a final vote it was shown the members did not approve of it. The branch will again donate $50.00 as it has in the past.

The chemistry class started a year ago is organized. The class attended the first lecture on October 7, 1931, and will meet every Wednesday night from 7:30 to 9:30 p.m. at the Vocational School. The class starts with 22 members. We have a Dan Wittig *Semi-Definite Plan.* Milwaukee Branch will have an open meeting on Thursday evening, October 22, 1931. All those interested in our work are cordially invited, especially platers, superintendents and managers.

Librarian Henry Binder has made arrangements with the American Brass Co. to give us a two-film illustrated lecture, "From Mine to Consumer."

Yours truly,

FRANK J. MARX, *Secretary.*

HARTFORD-CONNECTICUT VALLEY BRANCH

The Hartford-Connecticut Valley Branch, A. E. S., held its first fall meeting on Monday evening, September 28, at the plant of the McDermid Corp. of Waterbury, Conn.

Because of the fact that the Hartford Branch was acting host to the combined Connecticut branches, Waterbury was selected as the meeting place because of its central location to the branches concerned.

The meeting, which was planned to be more social than educational, was attended by about 65 members and visitors. The meeting in this respect was very successful, as it gave the different members an opportunity to renew old friendships. Everyone enjoyed refreshments, as well as the short talk given by Mr. Floyd Taylor, engineer for the Bullard-Dunn Co. of Bridgeport, Conn. Mr. Taylor's talk was on rheostats, which was ably given and made more emphatic by the diagrams drawn by him during his talk.

Due to the absence of all three Convention delegates and most of the officers as well, the usual business was dispensed with and the entire evening, with the exception of Mr. Taylor's talk, was taken up as a social affair.

We are indebted to the McDermid Corp. for their kindness in allowing us to use the rooms at the plant. The members who missed this meeting certainly missed a treat. Those who did attend were very enthusiastic in their praise to the committee in charge of the affair.

The meeting adjourned at a late hour with everyone expressing himself as having had a very enjoyable evening.

WATERBURY BRANCH

Mr. R. S. Leather, president of the Lea Manufacturing Co., entertained the members of Waterbury Branch and visitors with an interesting talk on "Abrasive Compositions" at their meeting Friday evening, October 9. The speaker included in his remarks an instructive description of the making of buff wheels. At the conclusion of the talk a number of questions were asked and the desired information furnished. In behalf of all present, President Leroy Miller extended the speaker a vote of thanks. Under the head of new business, Joseph Muscio, Henry Mahlstedt and Tennant Elwin were elected to the Board of Managers. Ellsworth Candee reported on the progress that was being made in laboratory matters. It was voted to endorse the dates of June 20, 21, 22 and 23, 1932, submitted by Philadelphia Branch as the time for the next convention. Several important matters being brought up for action were laid over. The librarian announced that the speaker for the next meeting, Friday evening, November 13, would be Mr. Arthur Tracey of the American Brass Technical Department, who will take for his subject "Corrosion of Metals."

W. F. GUILFOILE, *Secretary.*

DAYTON BRANCH

The regular monthly meeting of Dayton Branch was held Saturday evening October 3, 1931, at the local Y. M. C. A.

Due to the absence of our president, Mr. Cusick, Mr. Fraine was chosen to fill the chair for the evening.

Minutes of the previous meeting were read and so approved. In his remarks before the members of the branch, Mr. Fraine told of the advantage of belonging to an organization such as the A. E. S. and how the plater may be benefited by bringing his problems before the society for solution. Ours is an educational society, but the friendships and good fellowship alone are well worth all that it cost in the matter of dollars and cents, and it is our duty as members of the society not only to be present at the meetings, but to be faithful to our financial obligations to our branch as well.

In the near future members of the chemical control class will again be taking up their studies under the direction of Mr. Suman, our instructor; and it is needless to say we are looking forward with a great deal of enthusiasm for the roll call of the first meeting, and we would say to those who were not in the class last year: "Come in, the water is fine."

The discussions of the evening were of a somewhat varied nature. Chrome was the first topic for discussion and how much heat it would stand without tarnishing.

Low pH nickel also came up for its share of discussion for the evening. At this point we were amused at some of the things to be seen and heard while visiting the various plating shops of the country as told by Mr. Truman.

After quite a lengthy discussion on the different kind of pickles and their uses, the meeting was adjourned until the first Saturday in November.

WARD PROTSMAN, *Recording Secretary.*

APPLICATIONS

Branch

EDWARD BROWNING SANIGAR, 5042 Stenton Ave., Philadelphia (Assoc.)
Philadelphia
JESSE E. QUIMBY, 1816 Kinsey St., Philadelphia.....Philadelphia
JOHN YINGLING, J. B. Ford Co., 10 Chestnut St., Philadelphia (Assoc.)
Philadelphia
HENRY M. WRITER, 3rd and Segley Avenue, Philadelphia (Assoc.)
Philadelphia
ED. ENGLAND, 145 Delavan Ave., Newark, N. J. (Assoc.).....Newark
C. J. FRASER, International Nickel Co., Oak St., Bayonne, N. J.....Newark
M. C. HAY, 36 S. Munn Ave., East Orange, N. J. (Assoc.).....Newark
S. OLIN, 395 S. 15th St., Newark, N. J.....Newark
WM. JONES, 263 Havre Street, East Boston, Mass.....Boston
PATRICK H. O'CONNELL, 785 Monroe St., Brooklyn, N. Y.....New York

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ELECTIONS

EDWARD BROWNING SANIGAR, 5042 Stenton Ave., Philadelphia (Assoc.)
Philadelphia
JESSE E. QUIMBY, 1816 Kinsey St., Philadelphia.....Philadelphia
JOHN YINGLING, 10 Chestnut St., Philadelphia (Assoc.).....Philadelphia
HENRY M. WRITER, 3rd and Segley Avenue, Philadelphia (Assoc.)
Philadelphia
ED. ENGLAND, 145 Delavan Ave., Newark, N. J. (Assoc.).....Newark
C. J. FRASER, International Nickel Co., Oak St., Bayonne, N. J.....Newark
M. C. HAY, 36 S. Munn Ave., East Orange, N. J. (Assoc.).....Newark
S. OLIN, 395 S. 15th St., Newark, N. J.....Newark
WM. JONES, 263 Havre Street, East Boston, Mass.....Boston
ALBERT L. FRY, 162 Uhland Terrace, N. E., Washington, D. C.
Baltimore-Washington
P. W. STRAUSSER, Bureau of Standards, Div. 5, Sec. 6, Washington, D. C.,
Baltimore-Washington
WALTER SHELTER, 726 Macon St., Brooklyn, N. Y.....New York
BENJAMIN MENKIN, 1944 15th St., Brooklyn, N. Y.....New York
RALPH WELLRING, 1121 Applegate Ave., Elizabeth, N. J. (Assoc.)....New York

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RESIGNATIONS

J. YOUNG, 467 St. Clarens Avenue, Toronto.....Toronto
GEO. MUSCIO, 5529 Howe Street, Pittsburgh, Pa.....Pittsburgh
L. KONWALINKA, 1900 S. Ridgeland Avenue, Berwyn, Ill.....Chicago

SUSPENSIONS

JOHN E. LOHSTOETER, 119 N. Aiken Ave., Pittsburgh, Pa.....Pittsburgh
MILO J. STUTZMAN, 2801 Preble Ave., Pittsburgh, Pa.....Pittsburgh
WM. M. FISHER, 654 Gordon St., Reading, Pa.....Philadelphia
T. D. GAUL, 440 Woodward Street, Reading, Pa.....Philadelphia
C. R. MOYER, 529 Philadelphia Ave., Boyertown, Pa.....Philadelphia
M. REYNOLDS, 1809 Berryhill St., Harrisburg, Pa.....Philadelphia
E. COLES, 66 August Ave., Toronto, Canada.....Toronto
C. G. COLVILL, 911 Carlaw Ave., Toronto.....Toronto
S. FINLEY, 234 Ladie Ave., Orillia, Ontario.....Toronto
A. GROVES, Box 416, Carleton Place, Ontario.....Toronto
T. JOHNSON, 271 Spadina Rd., Toronto.....Toronto
A. W. JOHNSON, 318 Ashland Ave., London, Ontario.....Toronto
WM. JAFFRAY, 35 Eastwood Rd., Toronto.....Toronto
A. LAWRENCE, 577 Simcoe St., North, Oshawa, Ont.....Toronto
W. MACGILLIVIARY, 182 Inglis St., Sydney, Cape Breton, Nova Scotia
Toronto
A. T. MIDDLETON, 47 Vermont Street, Toronto.....Toronto
D. STIFF, 234 Deloraine Avenue, Toronto.....Toronto
H. WALLACE, 104 Marguerette St., Toronto.....Toronto
T. WAKEFIELD, 22 Manitoba St., Guelph, Ont.....Toronto
GEO. ZIMMERMAN, 915 Manning Ave., Toronto, Ont.....Toronto
J. D. OWENS, 644 Willard Street, Camden, N. J.....Philadelphia

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TRANSFERS

GEO. F. TURNER, from the Baltimore-Washington Branch to the Philadelphia Branch.

DEATHS

Mr. Jos. Underwood, secretary of the Philadelphia Branch, informs us of the death of MR. W. A. LAMBERT, 281 Grand Avenue, Johnson City, N. Y.

THE RIVER PATH

There's a path beside the river
Winding through the willow copse,
Where I love to walk in autumn
Ere the season's curtain drops.

On far hillsides beech and maple,
Touched by early nipping frost,
Have their brown and crimson jackets
To the boisterous breezes tossed.

Still the willow leaves are clinging,
Latest foliage of fall,
Shading yet my river pathway
Underneath the osiers tall.

On the wimpling water's surface
Drift a million truant leaves,
Stolen from the woodland reaches
By the wind, the prince of thieves.

All along the river edges
Verdure's turned to brown and gray,
Rustling through the dying sedges
Autumn's low voiced breezes play.

Nowhere sweeter walk or rarer
Than my path beside the stream.
There I love to stroll in autumn.
There to loiter and to dream.

FRANK FARRINGTON.

PHILADELPHIA BANQUET

at "*ADAMS*"

13th and Spring Garden Streets

November 21, 1931. Educational Session starts at 3.00

Manufacture of Photographic Records
by R.A. Dimon, RCA -Victor Co., Camden, N. J.

Anodic Treatment of Aluminum
by Edwin Joyce, Philadelphia Navy Yard

Preparation of Steel Prior to Electroplating
by George B. Hogaboom
Hanson-Van Winkle Munning Co., Matawan, N. J.

Plating of Chromium at High Current Densities
by Lieutenant A. Willink, Frankford Arsenal, Philadelphia, Pa.

BANQUET AT 7 P. M.

The farmer and his wife watched their dog as he chased madly down the track after the 4 o'clock train. He did it every day and always returned winded.

"I wonder why he chases that train?" remarked the wife, with her eyes on the little cloud of dust that showed where Rover was.

"That's not bothering me," answered her husband. "I'm wondering what he'd do with it if he caught it."

"Young man," said the old one, severely, "when I was your age, I, too, thought I knew it *all*. Now I have reached the conclusion that I know very little."

"Great Scott!" exclaimed the lad, in astonishment, "has it taken you this long to find that out? Why, I knew it the minute I saw you!"

An Irishman named Grogan had a severe attack of muscular rheumatism, and the doctor prescribed the application of a mustard plaster.

A day or two later he called around and asked Mrs. Grogan:

"How about that mustard plaster I prescribed for your husband?"

He said he nearly died when Mrs. Grogan answered:

"Shure, docthor, Oi couldn't make Moike ate more nor th' half av it!"

The tourist left the train at every station and went ahead to the baggage-car to ask if his trunk was safe.

"Are you *quite* sure," he asked the baggage officer for the sixth time, "that my trunk is safe?"

"Begorra, I wish the Lord had made ye an elephant, instead of an ass," was the exasperated reply, "an' then you'd always have your trunk in front of you."

One day a lady, who was soliciting, stopped at Mrs. Slattery's. She said:

"Mrs. Slattery, we are soliciting for a drunkard's home, and couldn't you give a little to help us out?"

"Certainly," replied Mrs. Slattery. "You come around at six o'clock and you can have Slattery."

In a certain church in Ireland a young priest was detailed to preach. The occasion was his first appearance, and he took for his text "The Feeding of the Multitude." He said: "And they fed ten people with ten thousand loaves of bread and ten thousand fishes." An old Irishman said: "That's no miracle; begorra I could do that myself," which the priest overheard.

The next Sunday the priest announced the same text, but he had it right this time. He said: "And they fed ten thousand people on ten loaves of bread and ten fishes." He waited a second or two and then leaned well over the pulpit and said: "And could you do that, Mr. Murphy?"

Mr. Murphy replied: "And sure, Your Riverance, I could."

"And how could you do it, Mr. Murphy?" said the priest.

"And sure, Your Riverance, I could do it with what was left over from last Sunday."

Wife (after midnight)—"I'm sorry to see you come home in such a state as this, Charles."

Husband—"I knew you'd be sorry, Carrie, and that's why I told you not to sit up."

A poor Irishman offered an old saucepan for sale. His children gathered around him and inquired why he parted with it. "Ah! my honeys," answered he, "I would not be after parting with it, but for a little money to buy something to put in it."

Young Sparker—"Bobbie, tell me (handing him a nickel) how many fellows have been to see Ethel this week?"

Bobby (aged six)—"Let's see—four."

"That doesn't include me, does it?"

"No; I heard Sis say you don't count."

"My father and I know everything in the world," boasted a small boy to a visitor.

"That so?" said the caller. "Where is Asia?"

After a moment's hesitation the youngster answered: "Oh, that's one of the things my father knows."

RESEARCH COMMITTEE

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Worcester Branch.....M. H. FROMMANN

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Other Branch Representatives will be printed as received.

ANDERSON BRANCH

Meets first Monday of every month at 7:30 p.m. at the Anderson, Indiana, Y. M. C. A. R. M. Wagner, Secretary-Treasurer, 23 W. 12th St., Anderson, Indiana.

BALTIMORE-WASHINGTON

Meets in Enoch Pratt Library, Calhoun and Hollis Sts., Irvin H. Hahn, Secretary, 207 S. Sharp St., Baltimore, Maryland.

BOSTON

Meets at American House, Boston, Mass. First Thursday each month. Secretary, A. W. Garrett, 45 King St., Dorchester, Mass.

BRIDGEPORT

Meets first and third Friday of each month at Chamber of Commerce Rooms, Stratfield Hotel. Secretary, T. H. Chamberlain, 869 Orange St., New Haven, Conn.

CHICAGO

Meets second Saturday of each month, at 8 p.m., Atlantic Hotel, 316 S. Clark St., Secretary, E. G. Stenberg, 2200 N. Kenneth Ave., Chicago, Ill.

CINCINNATI

Meets every Thursday, 7.30 p.m., at Vocational Training School, Spring and Liberty Sts. Secretary, Al Yeager, 2021 Sherman Ave., Norwood, Ohio.

CLEVELAND

Meets first Saturday of each month at Hotel Winton. Paul R. Stamm, Secretary, 947 Elbon Road, Cleveland Heights, Ohio.

DAYTON

Meets first Saturday of each month at the Y. M. C. A., Dayton, Ohio. Secretary, Ward Protsman, 141 Westwood Ave., Dayton, Ohio.

DETROIT

Meets the first Friday of each month at the Hotel Statler, Louis II Room. Secretary, Chas. M. Phillips, 18988 Hickory Ave., Detroit, Mich.

GRAND RAPIDS

Meets second Friday of each month at 528 Lake Michigan Drive, N. W. Secretary, Jacob Van Dyke, 1361 Union Ave., N. E., Grand Rapids, Mich.

HARTFORD-CONNECTICUT VALLEY

Meets fourth Monday in each month alternately at the Chamber of Commerce, 815 Main St., Hartford, and the Chamber of Commerce, 124 Chestnut St., Springfield. Secretary, Vernon Grant, 32 Jennings Road, Bristol, Conn.

INDIANAPOLIS

Meets second Saturday of each month at Hotel Denison. Secretary, Louis Mertz, 1725 Union St., Indianapolis, Ind.

LOS ANGELES

Meets second Wednesday of each month at the Chamber of Commerce Bldg., 9th floor, 1151 S. Broadway. Secretary, M. D. Rynkofs, 1354 W. 25th St., Los Angeles, Calif.

MILWAUKEE

Meets second and fourth Thursdays of each month at Cor. 3rd and Highland Ave., Frank J. Marx, 1431 W. Cherry St., Milwaukee, Wis.

MONTREAL

Meets second and fourth Friday of each month at 1437 Aylmer St., Montreal, Quebec, Canada, where the Secy-Treas. Mr. Charles Doherty, can be found at any time.

NEWARK

Meets first and third Fridays of each month at Franklin Hall, 41 Franklin St., Newark, N. J., at 8 p.m. Secretary-Treasurer, Geo. Rueter, P. O. Box 261, Newark, N. J.

NEW YORK

Meets second and fourth Fridays of each month in the World Building, Park Row, New York City, N. Y. Secretary-Treasurer, J. E. Sterling, 2531 40th St., Astoria, L. I.

PHILADELPHIA

Meets first Friday of each month in the Harrison Laboratory Building, University of Pennsylvania, 34th and Spruce Sts. Secretary, J. E. Underwood, 827 N. 10th St., Camden, N. J.

PITTSBURGH

Meets first Friday of each month at 8 p.m., at downtown branch, Y. M. C. A. Secretary, S. E. Hedden, 227 Fifth St., Aspinwall, Pa.

PROVIDENCE-ATTLEBORO

Meets first and third week of each month at 44 Washington St., Prov. Engineers Rooms, Providence, R. I. Notice by card. Secretary, J. H. Andrews, 19 Rosedale St., Providence, R. I.

ROCHESTER

Meet third Friday of each month at Hotel Seneca. Secretary, Chas. Griffin, 24 Garson Ave., Rochester, N. Y.

SAN FRANCISCO BRANCH

Meets at Plaza Hotel, San Francisco. Secretary, H. W. McKibben, 310 Tehama St., San Francisco, Cal.

ST. LOUIS

Meets second Friday of each month at the Plant of the Lacsalco Co., 2323 LaSalle St. Secretary, C. T. McGinley, 3214 Fairham Ave., University City, Mo.

TOLEDO

Meets first Thursday of each month at Toledo Secor Hotel, Cherry and Page Sts. James M. Lee, Secretary, Barker Street, Fremont, Ohio.

TORONTO

Meets fourth Monday of each month at Canadian Foresters' Hall, 22 College St., Room No. 2. Secretary, H. W. Graham, 102 Robina Ave., Toronto, Canada.

WATERBURY

Meets second Friday of the month at Engineers Hall, No. 11 East Main Street. Wm. F. Guilfoile, Secretary, P. O. Box 961, Waterbury, Conn.

WORCESTER

Meets Directors' Room, Chamber of Commerce, Worcester, Mass. Roger H. Bryant, Secretary, 94 Grove St., Worcester, Mass.